CROSS-REFERENCE TO RELATED APPLICATION

Applicant claims priority from U.S. Provisional patent application S.N. 60/443,467 filed January 28, 2003.

BACKGROUND OF THE INVENTION

This invention is a device for operating a valve that requires a large operating torque and that requires long term reliability, such as a valve that operates at the seafloor in a deep sea.

One type of main valve that requires high torque for operation and high reliability, includes a valve that controls the flow of drilling fluid, such as a water glycol mixture, to drilling equipment that drills into the seabed. A prior main valve of this type includes two metal discs, one pivoting on the other, and with passages that come into and out of alignment. The valve passes fluid from a high pressure source to a cylinder that uses the same or different high pressure fluid as to control the flow of the drilling fluid, or blocks the high pressure fluid while connecting the cylinder to a return. A high torque for a small valve, such as 120 inch pounds is required to pivot one of the discs with respect to the other, while the discs are pressed with high force against one another to avoid leakage at 17,500 psi.

The prior valve assembly includes a pilot valve that controls the flow of fluid at 5,000 psi, and which operates the main valve. The pilot valve is operated by a current of about one ampere at 12 to 24 volts. It was not practical to use a solenoid to operate the main valve, because of the very high current necessary to produce the required actuation force, and the consequent heating.

Experience has shown that the pilot valve is the most unreliable part of the prior valve design. The pilot valve often develops hydraulic fluid leaks of the operating fluid (5,000 psi), and other problems that lead to the need to replace the

valve at extreme inconvenience and cost. The main valve has proven to be very reliable but the overall reliability of the complete valve assembly has been limited by the problems with the pilot valve stage. Eliminating the problems with the pilot valve stage would produce a valve with a significantly improved reliability and a much lower operating and maintenance cost. This is especially critical in applications where access to the valve is limited, such as in subsea applications.

SUMMARY OF THE INVENTION

In accordance with one embodiment of the present invention, a valve operator of small size and high reliability for moving a moveable valve element with high force, includes a pair of electric gear motors. A first gear motor has a first driving member that moves the valve element to a connect position, the first driving member then withdrawing from the valve element. The second gear motor moves a second driving member that moves the valve element to a disconnect position, the second driving member then withdrawing from the valve element. In one valve, each driving member is a toothed rack that is moved linearly by a pinion or worm of the corresponding gear motor, and the valve element includes a bar-shaped handle, or force transmitter that receives forces applied by the racks to pivot a valve element disc.

A default mechanism senses when the pressure of a high pressure fluid has fallen to below a predetermined level, to then automatically moves the valve element to a selected position such as the disconnect position. When one of the gear motors moves the valve member from the disconnect position to the connect position, the force applied by the motor also moves the default mechanism back to an initial position.

The novel features of the invention are set forth with particularity in the

appended claims. The invention will be best understood from the following description when read in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a an exploded isometric view of a portion of a valve of the present invention, shown in an operated, or connect position.

Fig. 1A is a plan view of the valve frame of Fig. 1, and showing, in phantom lines, portion of the moveable valve element in the same position shown in Fig. 1.

Fig. 2 is a view similar to that of Fig. 1, but with the valve element in a disconnect position.

Fig. 1A is similar to Fig. 1A but with the movable valve element in the disconnect position.

Fig. 3 is a more complete isometric view of the fluid valve of Figs. 1 and 2.

Fig. 4 is a plan view of the valve of Fig. 3 with the force transmitter of the valve element shown in solid lines in a connect position and shown in phantom lines in a disconnect position.

Fig. 5 is a partial sectional side view of the default mechanism of the valve of Fig. 4.

Fig. 6 is a plan view of a valve of another embodiment of the invention wherein the gear motors turn cams that slide a valve element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Fig. 3 illustrates a valve assembly 10 which includes a shear valve 11 of the type that has a stationary disc 12 of a valve frame 13, and that has a pivoting disc 14 of a movable valve element 15 that can pivot about an axis 16. The valve element 15 includes a force transmitter 20 in the form of a bar or handle. The force transmitter 20 can be pivoted to move the pivoting disc 14 between two

different valve positions. The force transmitter 20 is pivoted in clockwise (looking down along axis 16) and counterclockwise directions by a valve operator 18 that includes first and second brushless gear motors, or gear motor assemblies 22, 24. The gear motors have intermediate shafts connected to pinions (or worms) 30, 32 that move driving members, or operators in the form of toothed racks 34, 36 in forward and rearward directions F, R. The driving members pivot the handle 20 and pivoting disc 14 between its two positions (bearings for the racks are not shown).

Fig. 1 is a simplified exploded isometric view of the shear valve 11 in an operating, or connect position. The shear valve includes the stationary disc 12 of the valve frame and the pivoting disc 14 of the movable valve element. The discs have surfaces 40, 42 that lie facewise against each other and that are pushed with high force against one another. This type of valve has been proven to provide a secure seal for high pressures, over a long period of time, although considerable torque is required to pivot the disc 14. In an operating (connection) position of the valve illustrated in Figs. 1 and 1A, a pressure source labeled P is connected through a passage 50 in the stationary disc 12, through a passageway 52 in the pivoting disc, to a passage 54 in the stationary disc. Only the ends 56, 58 of the passageway 52 are exposed. The passage 54 leads to a customer port C to supply high pressure fluid thereto. At the same time, a passage 60 in the stationary disc, which is connected to a return, labeled R, connects to a passageway 62 in the pivoting disc, the passageway 62 not leading anywhere (it ends at location 63). Thus, in the operating position of Figs. 1 and 1A, which can be referred to as a connect position, the pressure source P is connected through the valve to a customer port C, while the return R is not connected to anything.

Figs. 2 and 2A illustrate the valve 11 in a default, or disconnect position, after the pivotable disc 14 has pivoted in the clockwise direction by an angle A

such as by 20° from the position of Fig. 1. In the default position, which can be referred to as a disconnect position, the pressure source P which is connected to the passage 50, is not connected to anything, but leads to area 65 on the pivoting disc. This is because opposite end of the passageway 52 in the pivoting disc open to areas 64, 66 on the stationary disc which block the passageway 52. However, the customer port C is connected through passage 54 in the stationary disc through passageway 62 in the pivoting disc, and passage 60 in the stationary disc to the return R. Applicant notes that the stationary disc has a land 70 that is highly polished, to avoid leakage when the discs are pressed against one another. The force with which the discs are pressed against one another, depends upon the pressure of the fluid that will pass through the valve.

Fig. 4 shows the force transmitter, or handle 20 in the connect position. To operate the valve to the disconnect position, the first motor 22 is operated to rotate its pinion 30 so it rotates in a clockwise direction to move its rack 34 in the forward direction F. A front end 35 of the rack moves to 35A while it pushes a first end 80 of the handle 20 in a clockwise direction to move the valve 11 to the initial, or disconnect position of Figs. 2 and 2A. A control 82 that controls operation of the motors, senses that the rack 34 of the first motor has reached its frontmost position at 35A and immediately (preferably less than a minute) reverses the motor 34. The rack then moves rearward R to its initial position, the motor then stopping. Sensors 84, 86 can detect the extreme rack positions. When the valve is to be moved to its operating, or connect position, the second motor 24 is energized to move its rack 36 in the forward direction F sufficient to pivot the handle counterclockwise from 80A back to the position 80 illustrated in solid lines in Fig. 4. The second motor then turns in reverse to return the rack 36 to its initial position.

Small gear motors of high reliability, and with a large reduction gear train, are available at moderate cost. The large force that such gear head motors can apply, using only moderate current to move the rack with a large force because of the large gear reduction, enables pivoting of the valve without the need for a pilot valve and consequent fluid leakage of such pilot valve. The fact that each circuit that drives a gear head motor, moves the rack forward and then rearward assures that the rack is out of the way when the other motor is operated. This also provides the advantage that the valve can be moved to a default (disconnect) position if there is a drop in fluid pressure.

As mentioned above, the valve 11 was designed to pass or block a high pressure fluid, such as at 17,500 psi. One requirement of the valve is that, if the pressure of the fluid being passed through the valve or of another high pressure fluid drops to a low level such as below 2,000 psi, that the valve revert to its default (disconnect) position wherein the high pressure source is blocked from the cylinder C. Applicant provides a failsafe mechanism 90 that moves the valve element handle 20 to the default position indicated at 20A in Fig. 4, when the pressure of a particular fluid applied to the mechanism drops below a predetermined level. The failsafe mechanism 90 shown in Fig. 3, includes a first plunger 100 that slides within a sleeve 102 that carries a compression spring 104. The spring biases the plunger in a rearward direction R to tend to push the valve handle 20 to the default position shown at 20A in Fig. 4. However, a second plunger 110 is biased upwardly by the pressure Q of a fluid that controls the default mechanism. A second spring 112 biases the second plunger 110 downwardly, but normally cannot overcome the upward force Q applied by the pressured fluid.

Fig. 5 shows how the second plunger 110 engages a shoulder 114 on the first plunger 100 to prevent its rearward R movement. When the pressure Q drops

below a predetermined value such as 2,000 psi, the second spring 112 pushes down the second plunger 110 to release the first plunger 100. Then, the first plunger 100 pushes the valve handle 20 to the default (disconnect) position 20A. The next time that the second motor 24 (Fig. 4) is energized to move the valve handle to the working (connect) position at 20, the force applied by the second rack 36 pushes the valve handle with sufficient force to overcome the force of first spring 104 and pushes the first plunger 100 to its initial position. The first plunger 100 is automatically held in its first position by the second plunger 110 which is moved upward by the fluid pressure (assuming the fluid pressure is at least 2,000 psi).

Although the figures show a valve with two members in the form of discs having facewise adjacent flat faces, with one of the discs being pivotable, it is possible to have a valve with stationary and moveable valve members, where the moveable valve member slides linearly instead of pivots. In that case, the rack of one of the gear motors can be used to slide the moveable valve member in one direction, and the rack of the other gear head motor can be used to slide the moveable valve member in the opposite direction. Fig. 6 illustrates another arrangement, wherein gear motors 120, 122 slide a slideable valve element 130 in forward F and rearward R directions on a stationary valve frame 132. In this arrangement, each motor turns a corresponding cam 134, 136 by a full turn, and then stops, whenever the valve condition is to be changed between connect and disconnect. Halfway between a full turn each cam such as cam 134 at 134A, has moved the valve element to a selected position 130A and has then "gotten out of the way". The failsafe mechanism 90 (which lies below cam 136) returns the valve element to a selected position when the fluid pressure falls below a preset limit.

Thus, the invention provides a valve of the type that avoids leakage by pressing a moveable valve element tightly against a stationary valve frame, and

that has a compact operator for moving the moveable valve member with a high force, which avoids the need for a pilot valve and avoids consequent leakage, and which provides a greater lifetime of valve operation. Applicant uses two gear motors, each operated to move a driving member that, in turn, moves a force transmitter such as a handle of the moveable valve element to a selected valve configuration such as a connect or disconnect position. After a driving member, or driver, has moved the valve element, the gear motor reverses to withdraw the driver from the moveable valve element. Each driver can be a linear moving part such as a gear rack, or a pivotable part such as a rotating cam. A failsafe mechanism includes a spring-biased plunger that is released to move the valve element to the default position when a fluid pressure drops below a predetermined level. The plunger is returned to its standby position the first time that the valve handle is moved to the working position.

Although particular embodiments of the invention have been described and illustrated herein, it is recognized that modifications and variations may readily occur to those skilled in the art, and consequently, it is intended that the claims be interpreted to cover such modifications and equivalents.